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Research

Surfaces: Concept, Design, Parametric Modeling and Prototyping

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Abstract. Our experiments are intended to refocus attention on the study of geometry, in particular on ruled surfaces, their possible discrete forms and/or development in the plane. The study of geometry is oriented to the concept, formal and expressive control, and built form. We begin with the critical analysis of the geometric shape, go through the problems of its virtual representation – also in parametric form – and finally transform it into a physical object with simple prototyping equipment that, on a small scale, reproduces a process repeatable at the large scale of architectural building. This is therefore a digital approach with roots in descriptive geometry. During our experimentation several models were realized, both parametric and physical. Today models can assist in experimental testing and are useful instruments for showing how the research was carried out.

The changing role of the architect

When in 1418 the Opera del Duomo in Florence announced the competition for the dome of St. Maria del Fiore, Filippo Brunelleschi and Lorenzo Ghiberti were appointed its master builders. The size of the dome imposed new construction technologies and the dome had to be self-sustaining during the construction. Giulio Carlo Argan, in his book *Storia dell'arte italiana*, says: *La nuova invenzione tecnico-formale non può più essere attuata con i vecchi procedimenti costruttivi, con l'esperienza di cantiere delle maestranze tradizionali: ora l'architetto è il solo responsabile del progetto, le maestranze debbono soltanto eseguire* (the new technical-formal invention can no longer be implemented with the old manufacturing processes, with the experience of the traditional workers: now the architect is the only one responsible for the project, the workers have just to execute it) [Argan 1973: vol. II, p. 97].

Vitruvius considered the architect to be a connoisseur of grammar, music, painting, sculpture, medicine, geometry, optics, philosophy and history:

> The architect need not and cannot be a grammarian of the stature of Aristarchus, though he must not be an illiterate; nor a musicologist such as Aristoxenus, though he must not be ignorant of music; nor a painter like Apelles, though he should not be incompetent as a draftsman; nor a sculptor like Myron or Polyclitus, though he should not be ignorant of the techniques of sculpture; nor, again, a doctor such as Hippocrates, though he should not be entirely ignorant of

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medicine; nor indeed should he be outstanding in any one of the other sciences, though not incompetent in any of them (Vitruvius, Bk. I, ch. I [2009: 11]).

The architect, coordinator of craftsmen, technicians and experts, should know all the features of the shape, even the most intimate ones, in order to determine them clearly. The dimension of craftsmanship, that is, the relationship between the architect, the artisan and technician, which characterized the quality of the architectural profession up to the pre-digital era, tends to fade away day by day, overwhelmed by the sudden evolution of "areas of knowledge" and the consequent extreme specialization of the professional figures who gravitate around the project.

That close connection between designed form and constructible form, which in the past resided in the mind of a single designer, is now dispersed among different professional competences. The designer perceives a form, a second professional translates it – modifying it – into a virtual geometric model, a third – modifying it again – renders it constructible.

In the transition from imagined form to virtual shape to built object, which is subject to the laws of nature, the transformation can be so radical that the qualities of the original shape are often significantly changed.

The emerging generations appear to be as masterful of new technologies as they are unmindful of the design experiences of the past focussed on the complexity of shape and on its realization. Consider, for example, the architectural surfaces used for roofing, which better lend themselves to expressive and formal research: a quick look at the panorama of the architecture currently being built is sufficient to establish how widespread the difficulty is of expressing complex shapes without falling into the singularity of the constructive process.

The architect's role has been transformed. The understanding of the relationship between form and technology, which made the architect superior to a craftsmen, indeed a director of craftsmen, has been radically altered, making increasingly evident the distance between the designer as a creator whose role is to produce the image, and the technician in charge of its implementation.

This leads to a sort of contradiction. Today we have highly skilled technicians and experts of advanced technologies who build unique pieces of architecture, consisting of many individual pieces assembled in specific and unique positions, but all these individual parts transform the object into a handmade product. In other words, the technician, thanks to technology, becomes an artisan in order to realize the formal will of the architectural object.

On the other hand, this representation of the unique shape, so closely tied to the image composed of pieces assembled in specific and unique positions, involves a significant economic investment, creating a clear break between an "everyday" architecture and an exceptional architecture that is suitable only for satisfying the desires of wealthy clients.

Yet, despite these contradictions, architecture is assuming a new role and a new relationship with space and time, accepting conformations that change in response to different constraints and assuming different meanings.

This architecture overcomes spatial and temporal characteristics and offers a new way of looking at the project, which is no longer confined within a specific stage of the production process of architecture but continues to generate and reorganize itself, constantly interacting with the life that the architectural organism suggests over time.

We must therefore consider architecture as an organism capable of modifying its formal and functional conditions according to the various stimuli, both external and internal, to which it is subjected: works of architecture with specific physical qualities and personalities, capable of reacting to all the conditions to which a natural and social organism can react.

We have been accustomed to think of the project as a result of information management that finds its conclusion in the work itself. Images, design data, operating data, distributive and formal choices are processed and transformed by the mind of the designer into the object of architecture. Now however we are more and more conscious of a radical change, where the designer works in a wider dimension in which he coordinates and compares real and virtual relationships. These connections occur simultaneously during the design phase, which does not end with the realization of form, but continues until the relations triggered come into existence, creating "living models". The architecture becomes a structure that mutates in space and time and thus moves dynamically according to different conditions determined by several kinds of input to which it is predisposed to react. Within this new system the designer is the one who determines the predispositions, creating virtual bridges between kinds of input that can be also vary in nature. The result of the process becomes the hybridization between the input introduced and the routes conceived. The process results in actions which not only create form, but also activate it. Thus we have an architectural organism capable of taking information, processing it and reacting intelligently, from a design point of view, to these data. The definition of the process can be also of a cyclical nature, giving rise to the output that provides new fuel for the process of searching for a balance between the organisms in the system. Within the new panorama, architecture is no longer the conclusion of a design process, but a moment in the process itself.

Let us imagine such an architecture. It reacts to climatic conditions by orienting and changing itself in order to absorb the rays of the sun optimally; it changes the geometries in function of the number of people who benefit from it or the different activities that take place within it; it is capable of transforming itself to play a certain role or assume a certain shape within a larger complex, as a urban environment. It is an architectural organism that changes in order to respond to internal and external influences, which are analyzed and controlled in such a way that this architecture determines itself in the best way possible.

We are talking about architectural organisms in which the form is mutant and mutable, capable of adapting itself to different conditions. Examples of it already exist: research in new sustainable technologies applied to architecture; the moveable roof structures of Santiago Calatrava, capable of optimizing ventilation and shading; the Blur Building of designers Diller & Scofidio, which can analyze the number of people present and the direction and force of the winds transforming them into parameters capable of modifying the vapour cloud that surrounds the project.

Mutating form

Our research investigates two aspects of form: its dynamic and changing declination, and the economy of its construction. We are convinced that it is possible to treat highly complex forms through solutions that are cost-effective.

We have thus tried to approach a theme that symbolizes architecture – roofing – with a spirit that is strongly expressive of design and craftsmanship, uniting experimentation with what is offered by new technical and computer technologies in order to resolve the problem of roofing with simple constructive strategems. We first thought of using wood as the material for experimentation, then imagined working with simple tools for woodworking. To satisfy our desire to define pieces that were easy to construct, we assumed the wooden board as a constructive form, and cuts were always made vertical to the working plane. Because we wanted to maintain a link with current architectural forms, we investigated the hyperbolic paraboloid. Among forms that are not new but which provided inspiration, we can mention the Philips Pavilion (Poème électronique) built by Le Corbusier in Brussels in 1958, as well as the works of Felix Candela, Renzo Piano and Santiago Calatrava. We also studied the experiments by Pier Luigi Nervi with ribbed architecture.

With the objective of reducing the number of elements necessary to build a roof (standardization), we started our research by studying an equilateral hyperbolic paraboloid (fig. 1). The director planes are mutually perpendicular and every generatrix makes equal pairs of angles with the directrix on which it rests. Further, the planes of symmetry divide the hyperbolic paraboloid into equal parts.

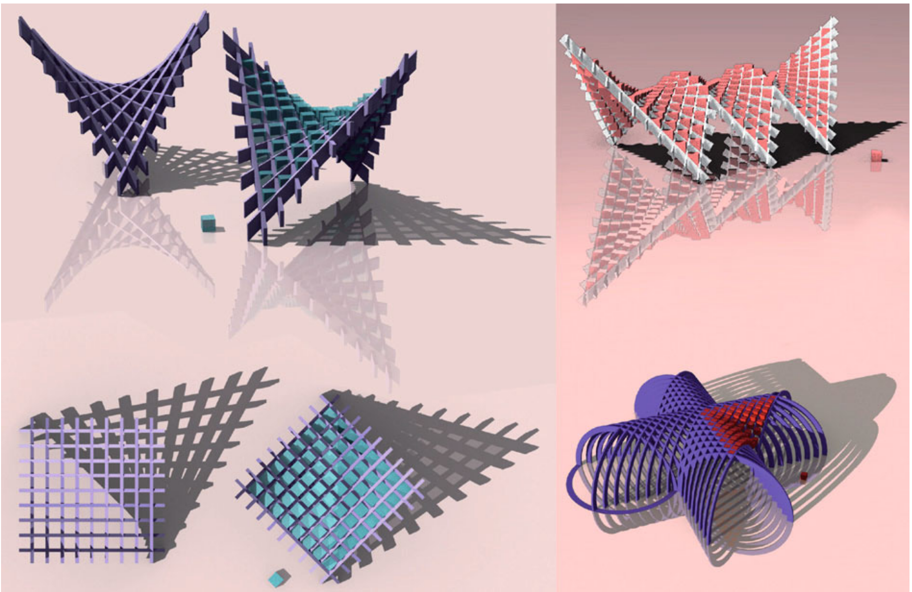

Fig. 1.

As can be seen, geometry is the basic matrix for the analysis, design and transformation of the form.

Now let us go into our experiments in greater detail. The vertical boards, supported on the double row of generatrices, intersect to form right angles, thus leading to the ease of cutting that was one of our goals. Their horizontal projection defines a regular square grid, therefore a square-based rectangular parallelepiped can fill the spaces between the generatrices.

What is this rectangular parallelepiped? It could be be a sheet metal box, or a tile of reinforced concrete and glass, or a mixed structure that can filter or screen light, or even a support to hold solar panels.

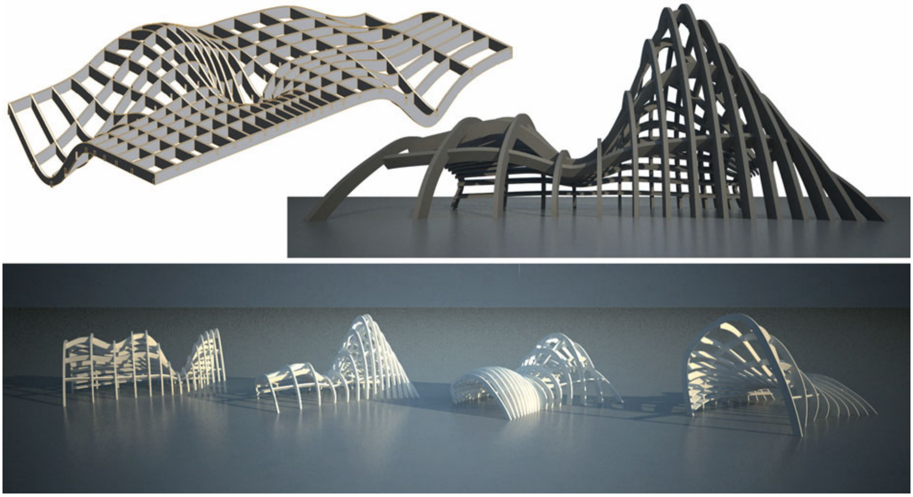

Fig. 2.

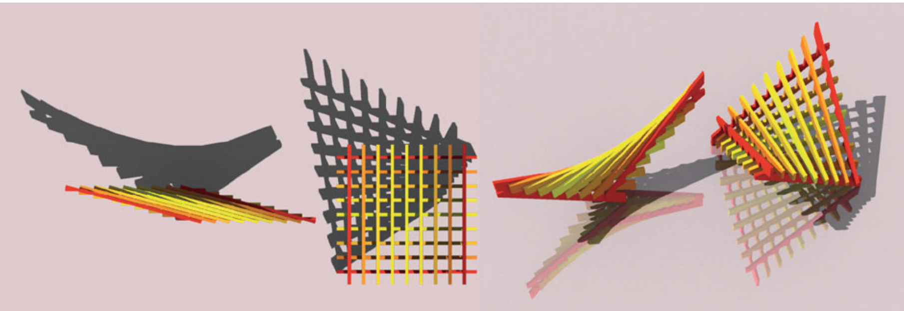

Fig. 3.

The structure is formed by four types of boards that are repeated four times, then a single axial type board that is repeated twice, and finally a series of sixty-four rectangular parallelepipeds used to fill the empty space.

The structure is very easy to build because the joints are always vertical. We consider it a complex form realized through simple means and solutions.

In this first experiment it was already possible to set up some automatisms that can change fundamental parameters appertaining to the nature of the structure decided upon. This means that the imput parameters adopted to modify the form are closely linked to the geometric conditions of the hyperbolic paraboloid.

For example, if the size of the structure is increased, its projection on the ground must be maintained square in order to respect perpendicularity of the director planes; if the number of beams in one direction is increased, then the number of beams in the other direction must also be increased by the same quantity, to guarantee inclusion of square elements.

During the design process, the changeableness facilitates the choice of the best form in terms of adaptability to a given context while leaving the initial geometric conditions unaltered.

What happens at the end of the process is a sort of freezing that produces a model selected for its suitableness for the boundary conditions. At this stage no activation of form occurs.

The free-form was also analyzed and constrained to specific construction choices, so as to obtain a balance and relationship between technology and forms of implementation. To simplify the joint, the structure is built from a grid of vertical beams which is intensified in order to describe and react better statically to variations in the form. The beams can all be directed towards a horizontal axis and can vary in number to optimize and filter sunlight in an indoor environment.

Let's return to the paraboloid. Considering that the basic shape is quadrilateral and the portions of empty space between the double series of generatrices are quadrilateral and equal, we considered the possibility of associating a dynamic action – movement – capable of varying the form of the structure.

Thus the joints have become nodes, vertical pins which allow only horizontal movement of the generatrix beams.

We can therefore imagine roofs built of hyperbolic paraboloids, which, when not in use, an all be gathered together on a beam and then opened completely to assume the square configuration.

The form becomes dynamic, capable of changing its spatial configuration and of performing several different formal and functional tasks.

From these first experiments we then went on to a new field of interest: the study of the plane surface and the possibility of intervening in its spatial configuration through a series of folds. In this new trial as well, economy, that is, the possibilities of realising the structure through simple and repetitive operations, was a guiding force in our research.

We named the surfaces we explored "articulated folded surfaces". While for their representation and construction non-developable surfaces require specific tesselations that adapt in the best possible way to the surface itself, leading to an object that is static, folded surfaces are exactly the opposite: they start with specific tessellations that make it possible for the surface to assume different forms in time and space, giving rise to an object that is dynamic, changeable.

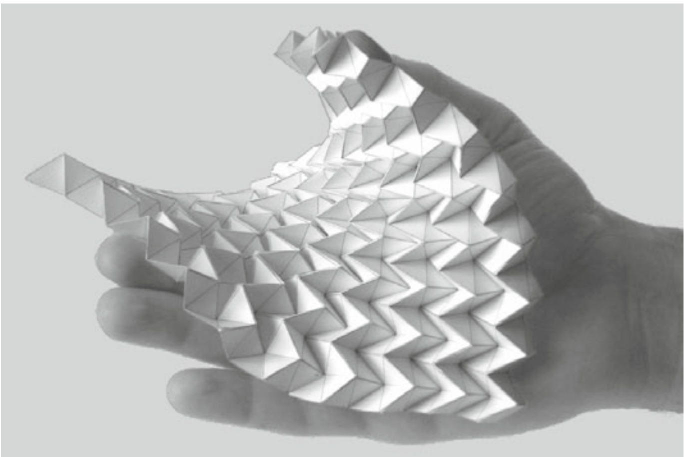

Fig. 4.

The instrument of our experimentation is the main element of the geometry, that is, the plane, which, when properly folded, changes and takes on new meanings in space. The shape is therefore modified, evolving within a range of changes comprised between two values, the initial one in which the shape is lying on the plane, the final one in which the form cannot move because the sides or the vertexes of its parts touch one another. Between these two conditions the form can assume an infinite number of possible configurations, which we can control through their associations to specific and identifiable geometric connections.

The parametric definition of a structure like this is obviously characterized by a greater complexity. The necessary condition is movement, which is first a consequence of the flat drawing of the tessellation and then of the type of action that the structure is subjected to.

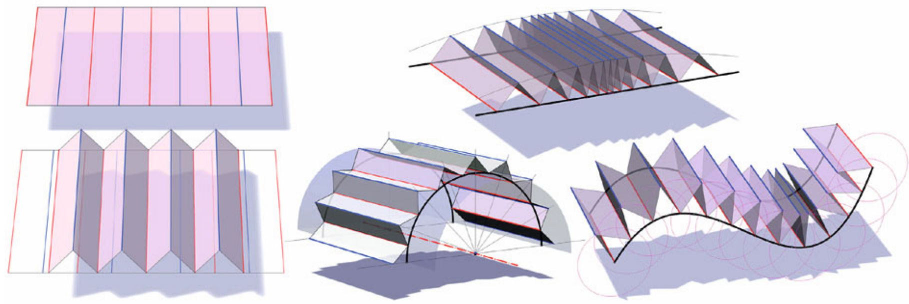

Fig. 5.

We were able to distinguish three structural families of folds that determine three types of configurations to which the plane is subject. The first type is identified by subjecting the surface to a dense and disordered tessellation; the plane may be deformed by assuming infinite configurations in space that are possible but difficult to control. For this type it is possible to guide the surface to assume a specific spatial configuration, but there is no guarantee of complete control, determined by a number of actions that are undefined on the planes of the disordered tessellation, forced to move about different hinges. In the second type the surface is subjected to a specific tessellation made up of several polygons selected in order to reach a specific configuration. In the third case, when a specific tessellation is determined as a result of a division of the surface into elements equal to each other, the surface can assume many different spatial configurations. These last two types offer a finite number of identical elements, linked by hinges that repeat and alternate, making it possible to design relationships that are decidedly easier to control.

One example

Let's start with a rectangular portion of the plane. We make a series of folds that are opposite and parallel. The plane stiffens in the direction of the folds. We can pull the folded surface, reducing the height of the ridges and increasing the portion of the roofed surface, but we can also curl it, supporting it on the surface of a cylinder; the bent surface would fit only if the folds follow the direction of the axis of the cylinder.

We can try to make additional folds along the diagonals of the rectangles produced by the first operation. The surface has changed its characteristics and reacts differently to our solicitations. It has maintained the ability to stretch, but this stretch may be different for each of the two opposite sides of the direction of the folds; it may shrink on one side and expand on the other, assuming a shape close to a triangle, like a fan. If we twist this surface by supporting the borders on two skew lines, we find that it takes the shape of a hyperbolic paraboloid. A roof covering that starts out flat can, by means of simple mechanical devices, take on a new and alternative spatial configuration.

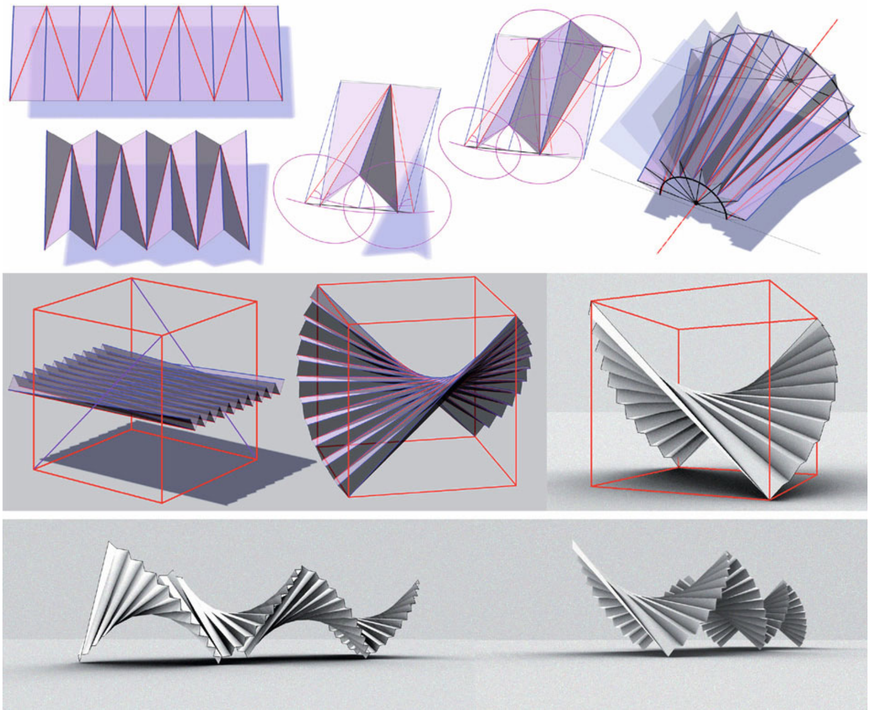

Fig. 6.

We can anchor a segment of the border to a straight line and guide the surface so that it follows a curve: such a surface describes a conical wedge. When in a state of rest the roof is flat but then, guided by the movement of the curve, it opens.

Thus in its initial state the folded surface can lie flat within the plane, and its final state can be perpendicular to the first, so that each triangle rests against the ones before and after it. It can assume an infinity of other positions between these two conditions, from covering the rectangle or the triangle in the plane, to adapting itself to a ruled surface.

If we think of this shape as being composed of rigid and hinged triangles, according to the folds that we proposed in our experiment with a sheet of paper, it is easy to imagine a roof built according to these geometries. By varying the relative positions of the modules, we can cover very different kinds of spaces. Further, if the surface is provided with an automatism, it can to vary its spatial configuration by adapting itself to different formal and functional demands to cover very different spaces.

A second set of folds completely changes the conformation of the folded surface. These folds are transversal to the first ones and have the function of changing the direction of the first folds: the fold that moved upwards moves downward once it meets the new fold: as shown in our example, the blue fold becomes red and the red one becomes blue.

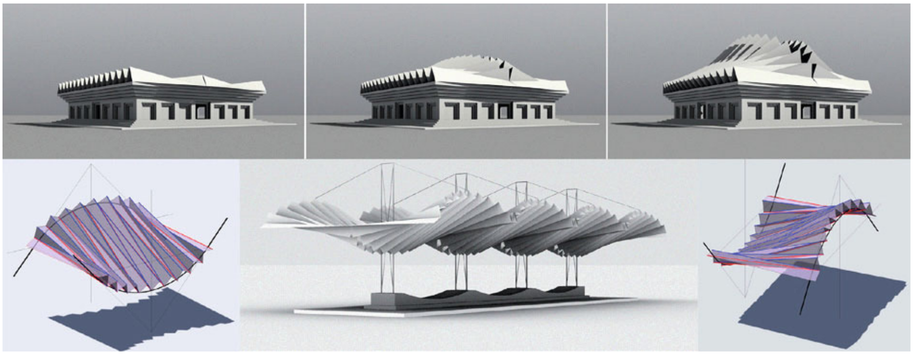

Fig. 7.

The introduction of this new family of folds makes a radical change in the spatial configurations that the surface can assume.

In this case as well it is possible to identify two groups according to the disposition taken by the folds of this new family. These may be "parallel" or "opposite". The "parallel" groups have alternating directions, are arranged in herring-bone patterns, and the surface when folded tends to remain flat. The "opposite" ones maintain the same direction, and when folded the surface tends to close onto itself.

Now it is easy to imagine surfaces produced by the contemporary coexistence of the two ways of distributing these folds, but it is harder to imagine what kind of configurations the surface can assume in space.

It is still important to note that the behaviour of the surface is fundamentally different depending on whether it is divided into triangles or polygons.

The polygon is the fundamental matrix both for its structural characteristics and most of all for its geometrical characteristics, and the fold-hinge constitutes the restraint that makes possible the controlled passage from one spatial situation to another.

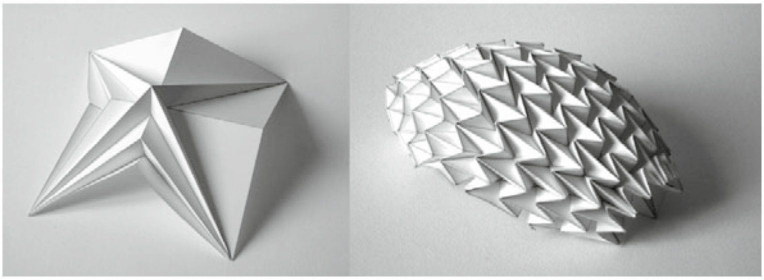

Fig. 8.

The geometric stiffness of the polygon makes it possible to control the spatial relationships between polygons as they move. The motion of vertexes that are opposite to the common hinged side describe arcs in planes that are perpendicular to the hinge. The radii of the arcs are the distances of the vertices from the common hinge. If we now imagine a third polygon hinged to the second, this too will move obeying the same rules, but this movement is added to the movement that the previous polygon has already been subject to. Consequently, in a configuration of a certain number of these, the movement of each polygon is constrained by and constrains the movements of all the polygons involved in the composition.

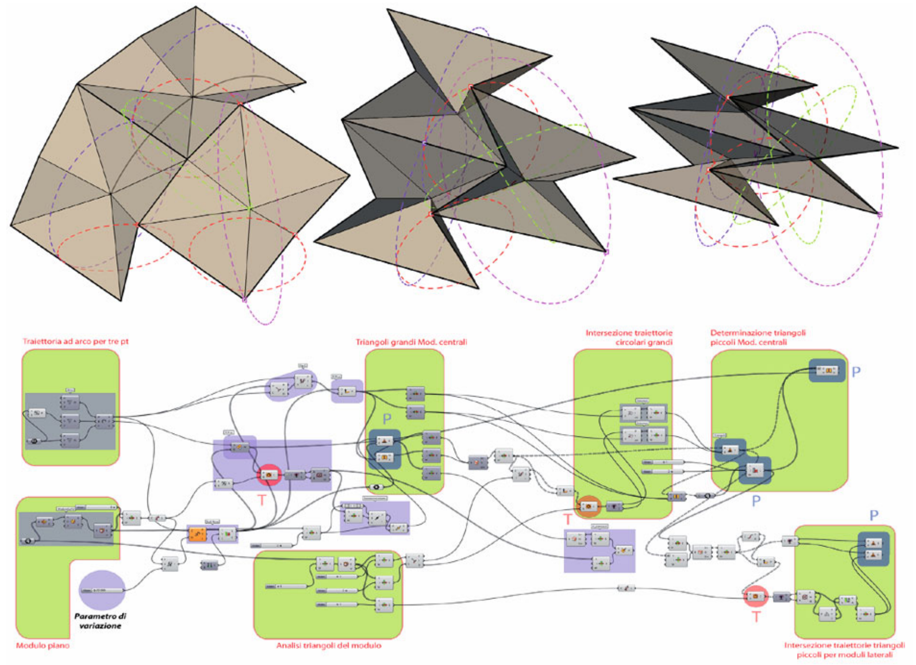

Fig. 9.

The single polygon is considered as a rigid geometry that can be moved in space but whose angular measurements and lengths of the sides never change; instead what does change in the composition of polygons is the angular relationship between them. Each polygon is attached by hinge-folds to those around it and thus can move only within the range permitted by the relationships presented by other adjacent polygons, which in turn are linked by similar constraints to successive ones. Each additional fold-hinge is subject to specific conditions and should facilitate the movement of the polygon in the direction of movement proposed by the previous polygons hinged together. Thus the fold must be chosen in a specific area to ensure all previous and subsequent relations. The possible arrangements are determined both by the linear and angular sizes of the polygons as well as by the direction of the hinge-folds that link them. The limit of the movement is related to the rigidity of the module; movement is possible until two vertices or two sides of two distinct modules touch.

Other examples

- Surfaces which close on themselves;
- Surfaces of small movements that maintain a bond with the initial geometric condition;
- Surfaces of maximum movement and flexibility.

The study and the representation of these folded surfaces demand the simultaneous application of all methods of representation.

From the two-dimensional model to the parametric model through the physical model

The two-dimensional model is reduced to a condition of maximum conciseness. It is essential to verify on the plane the two boundary conditions that the surface can take.

This is a schematic representation which shows, by means of different colors, the direction that the fold should take in space.

One can talk about a tessellation or texture that has as a matrix the natural divisions of the plane into simple polygons without spaces or gaps.

These polygons can be further divided according to secondary geometries deduced from the main ones.

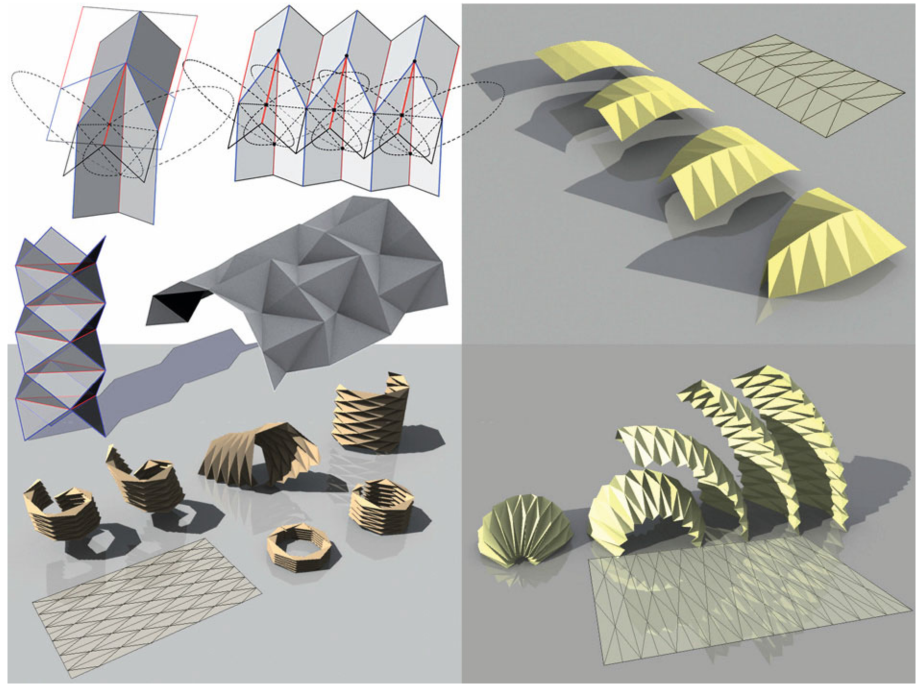

Fig. 10.

The geometries indicate the folds that are possible. Marking in blue the positive folds, which initially moved upward with respect to the flat plane, and in red the negative folds, which moved downward, we have the different spatial configurations. The module consists of group of polygons and folds that are oriented before these repeat themselves in the pattern.

It is only through imagination and careful analysis of the configuration described two-dimensionally that it is possible to foresee first the movement of the element and then that of the module, that is, of the group of elements before their repetition, and thus it is possible to deduce the tendency of the folded surface to take a possible given configuration in space.

At this point it is necessary to use a physical model. This allows us first to verify the correctness of our deductions, and then to verify how the movement of the smallest piece and of the module is reflected into space and what arrangements of these are possible, under what conditions they move, and whether it is possible to identify a spatial geometry to which they can adapt.

Here we arrive at the only instrument capable of controlling and representing an object provided with such freedom of shape and spatial configuration, that is, the parametric model. First, we can impose the relationships of movement among the smallest triangular pieces. Second, this parametric model allows us to verify the formal qualities that the folded surface assumes with the movement in time following the spatial geometric specifications established by the designer.

We have therefore developed a systematic approach in which it is possible to define in a synthetic way the relationships inherent the movement of a single part, observing what repercussions this would have in the broader context of the surface, proposing a movement constrained only by geometric conditions.

The parameterization has been used as a vehicle that can reiterate geometric relationships between the modules aimed at guaranteeing the kinematic mechanism between the single parts. These geometric relationships are applied to reference systems that are themselves moveable, in that they are connected to the different positions that the hinge mechanism assumes during the general movement of the form. Paradoxically, the overall movement is related to the change of a single modular aggregation; by parameterizing the action on this, it is possible to change the entire form, creating variations closely related to the design of the articulated surface. The kinematic efficiency of this system is obvious: a simple action taken by a few simple mechanisms corresponds to a significant formal effect.

In order to solve the problem of the movement we have chosen to replace the mathematical and computational relationships with geometric relationships. We start from the description of any point belonging to a piece of the surface that describes a circular arc around its hinge during the movement. Going forward, we realize that their mutual relations are always described by intersections between arcs, or at most between spheres.

This geometric approach to the problem gave us the possibility of a precise control of shape and its possible configurations, turning the digital model into a virtual prototype from which to extrapolate the principles that govern the articulated surface; this awareness guides the arrangement of appropriate mechanisms. In addition, this approach permitted control of the critical issues of the shape, identifying in it possible breaking points and formal incongruities that we wished to avoid.

This cycle of experiments has suggested a new and important consideration, proposing the computer model as a real method of representation. In fact, while the most important quality of the methods deduced from descriptive geometry was the reduction of a three-dimensional space into a two-dimensional plane, and from the information drawn from this reduction it was still possible to reconstruct the object in space, today the computer model is capable of representing an object provided with a fourth dimension, movement, reducing it to three dimensions and giving us all the possible information to reproduce it in the four-dimensional space.

References

ARGAN, G. C. 1973. *Storia dell'Arte Italiana*. 3 vols. 4th printing. Florence: Editori Sansoni.

BURI, H. and WEINAND, Y. 2008. Origami - Folded Plate Structures, Architecture. In *Proceedings of the 10th World Conference on Timber Engineering*, Miyazaki, Japan (2-5 June 2008).

CASALE, Andrea. 2010. Geometria Creativa. Intuizione e ragione del disegno dell'oggetto. Pp. 5-213 in *Geometria Creativa. Intuizione e ragione del disegno dell'oggetto* (Nuovi quaderni di Applicazioni della Geometria Descrittiva, vol. 5). Rome: Kappa.

CASALE, Andrea, Graziano Mario VALENTI and Michele CALVANO. 2011. Tra rappresentazione e fabbricazione, dalla costruzione del modello al modello costruito. In *Le vie dei mercanti*. SAVE

Heritage Safeguard of Architectural, Visual, Environmental Heritage, vol. 10. Naples: La Scuola di Pitagora.
CHEN, H. Y. and H. POTTMANN, H. 1999. Approximation by ruled surfaces. *Journal of Computational and Applied Mathematics* **101**: 143-156.
CIPRA, B. A. 2001. In the Fold: Origami Meets Mathematics. *SIAM News* **34**: 1-4.
GHEORGHIU, A. and V. DRAGOMIR. 1978. *Geometry of Structural Form*. Elsevier Applied Science.
GUEST, S. D. and S. Pellegrino. 1996. The Folding of Triangulated Cylinders, Part III: Experiments. *ASME Journal of Applied Mechanics* **63**: 77-83.
HAASIS, M. and Y. WEINAND. 2007. Origamifaltwerke, Neue Anwendung für Brettsperrholzplatten. In *Praktische Anwendung von Massivholzplatten*. Dübendorf.
HUYBERS, P. and G. VAN DER ENDE. 1989. Uniform Polyhedra for Building Structures. Pp. 233-236 in *Symmetry of structure*, G. Darvas and D. Nagy, eds. Budapest.
ISSA, R. 2009. *Essential Mathematics for Computational Design*. Robert McNneel & Associates.
LORIA, Gino. 1912. *Poliedri, curve e superfici secondo i metodi della geoemtria descrittiva*. Milan: Hoepli.
MIGLIARI, Riccardo. 2009. *Geometria descrittiva - Tecniche e applicazioni*. Novara: CittàStudi – De Agostini.
VALENTI, Graziano Mario. 2004. MI Il modello integrato. Pp. 59-62 in *Disegno come Modello*, Riccardo Migliari, ed. Roma: Kappa.
———. 2007. HySpace: spazio virtuale parametrico per la fruizione interattiva di modelli digitali. Pp. 600-605 in *Sistemi informativi per l'architettura*. Firenze: Alinea.
———. 2008a. *De.form.are – De.form.ing*. Roma: Rdesignpress.
———. 2008b. HySpace 0.2. Pp. 222-225 in *Lo spazio digitale dell'architettura italiana, idee, ricerche, scuole, mappa*, Maurizio Unali, ed. Roma: Kappa
VITRUVIUS. 2009. *On Architecture*. Richard Schofield, trans. London: Penguin Classics.

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